[0028] According to some preferred modes of realization, the means for pumping the gain region may comprise optical pumping means.

[0029] The first mirror may comprise a Bragg Mirror with a succession of layers of higher and lower indices of refraction, so as to have a high reflectivity at the laser frequency.

[0030] It may for instance comprise 10 to 40 pairs of high/low index layers made of semiconductor or dielectric materials. It could be a hybrid mirror with a gold layer or coating added.

[0031] The second mirror may have a transmittance in the order of 0.1% to 15%.

[0032] The gain region may comprise 3 to 24 quantum wells separated with barriers.

[0033] According to some less preferred modes of realization, the gain region may comprise quantum dots.

[0034] With optical pumping, the microcavity with the gain region may be several $\lambda/4$ layer thick (λ being the laser wavelength), to allow absorption of the optical pump power in the barriers, or alternatively directly in the quantum wells (or quantum dots) to reduce heating. The quantum wells longitudinal distribution along the barrier layers may be optimized for homogeneous excitation of these quantum wells.

[0035] The thickness (or the length) of the gain region may be limited to only a few laser wavelengths to avoid the appearance of longitudinal spatial mode competition.

[0036] As set forth before, the invention aims at providing lasers which allow achieving high power, narrow spectral linewidth, low intensity noise and tunability.

[0037] It has been surprisingly discovered in the frame of the invention that the best trade-offs between these characteristics may be obtained with VeCSEL laser architectures in which the spectral ratio between the HWHM spectral bandwidth of the modal gain and the free spectral range (FSR) of the external cavity is in the range of 2 to 9 (robust), or in the range of 9 to 50 (but possible sensitivity to non-linear mode interactions at very high intracavity power).

[0038] This range of parameter allows keeping single frequency operation stable and robust.

[0039] This range of parameters allows also keeping characteristic time for single longitudinal mode operation much shorter than one millisecond, typically in the order of few microseconds, in order to avoid technical or physical perturbations.

[0040] The spectral bandwidth of the modal gain depends on the gain curve of the gain medium (the quantum wells) and on the resonance (or anti-resonance) spectral characteristics of the micro-cavity.

[0041] The free spectral range of the external cavity depends on its optical length.

[0042] So, according to the invention, keeping these parameters in relation as described before leads to optimal design trade-offs of VeCSEL lasers assemblies with specifications in terms of power, spectral linewidth, intensity noise and tunability which are not achieved by prior art devices.

[0043] As it will be explained, these design constraints may lead to a large variety of specific designs with different trade-offs and optimizations between the above mentioned specifications (for instance power, tunability . . .). However, they ensure that the trade-offs are optimal.

[0044] According to some modes of realization, the device of the invention may comprise:

- [0045] a microcavity with a length adjusted so as to meet an anti-resonance condition at the laser frequency; and/or
- [0046] an exit region with a spectral filter arranged so as to enhance the anti-resonance factor of the micro-cavity around the laser frequency.

[0047] The device of the invention may further comprise an external optical cavity with a length adjusted to be smaller than or equal to 2 mm.

[0048] Alternatively, the device of the invention may further comprise an external optical cavity with a length smaller than 0.5 mm.

[0049] These modes of realization allow obtaining a fast and broadly continuously tunable laser cavity, with tuning repetition rate up to few MHz.

[0050] For instance, for an external cavity length of 0.3 mm, the free spectral range FSR=500 GHz.

[0051] Applying an antireflection coating on the exit region and/or adjusting the length of the microcavity to meet an anti-resonance condition at the laser frequency allows obtaining a broadband gain, with a bandwidth in the order of 5 to 10 THz HWHM.

[0052] In these conditions, it is possible to achieve broad continuous laser frequency tunability (without mode hops) over more than 500 GHz at constant output power by varying the length of the external cavity, and even more by also tuning the semiconductor component temperature.

[0053] Of course, broader tunability may be achieved with mode hops.

[0054] Meeting the anti-resonance condition also allows reducing the electric field intensity in the semiconductor structure, for modal optical losses reduction (external cavity finesse increase, lower pass band filter of the intensity noise with lower cavity cut off frequency), thermal lens effect reduction and thermal noise induced frequency noise reduction. With an anti-resonant design, the finesse can be increased by a factor of 3, the thermal lens effect reduced by 3, and the frequency noise spectral density reduced by 10.

[0055] The antiresonance strength can be further increased by designing an anti-resonant microcavity. The length of the microcavity is still adjusted to an odd number of $\lambda/4$ layers (such as for the simple anti-resonant microcavity), but the exit region further comprises a bragg mirror with about 1 to 15 pairs of layers of higher and lower indices of refraction (instead of a simple transition between mediums of different indices of refraction such as for the simple anti-resonant microcavity).

[0056] The device may further comprise a capping layer to protect the semiconductor structure (GaAs, InGaP, Dielectric), whose thickness is included in the last top layer.

[0057] Of course, according to some other modes of realization, a spectral filter may comprise an element distinct from the semiconductor element.

[0058] These modes of realization allow doing free running lasers with high output power (of 1W or more) and very narrow linewidths, especially using the pump stabilization scheme for reduced thermal noise. The mechanical noise would be prevented from an integrated glued packaging.

[0059] According to some modes of realization, the second mirror of the device may be a concave mirror.

[0060] The device of the invention may further comprise tuning means for moving the second mirror so as to change